Biology, Specialization: Molecular Biology (MSc) – description of courses

1st year

1st semester

Courses	No. of hours	Lecture	Classes	Form of course completion	Credits ECTS	
					O	E
Advanced molecular biology[1)]	60	20	40 (Lab)	Ex	5	-
Molecular microbiology[2)]	60	20	40 (Lab)	Ex	5	-
Advanced biochemistry	60	20	40 (Lab)	Ex	5	-
Regulation of cellular processes	45	15	30 (Lab)	Ex	4	-
Analysis of biomolecules	45	-	45 (Lab)	Pg	4	-
Statistical methods in biology	30	-	30 (Lab)	Pg	2	-
Molecular evolution	15	15		Pg	1	-
Diploma seminar (I module - Writing and presentation of scientific papers)	30		30 (S)	Pg	3	-
On-line trainings: Work Hygiene and Safety (4 hours), Ethics and Disciplinary Liability of Students (2 hours), Library Training (2 hours)	(8)	-	-		-	-
Total:	**345 (+8)**				**29**	
					29	

Forms of classes (L – Lecture, Lab – Laboratory, K – Tutorial, S – Seminar); Ex – exam, Pg – pass with grade; O – obligatory course, E – elective course; 1) 2) elective complementary/extending courses will follow

Course name: Advanced molecular biology (USOS Code: B-BMOL.006)
Course coordinator: Prof. dr hab. Małgorzata Cytryńska
Prerequisites: Basic courses in biochemistry, microbiology, and genetics.
Course description: The first part of the course is focused on the introduction of the research case studies on current topics related to decipher intermolecular interaction between biomolecules, including protein-protein interactions. The intermolecular interplay within so-called bio-nano-machines will be considered to show the mechanisms that govern the biological processes on the atomic scale. Especially, the process of translation will be taken into consideration as an example of the biological event, where nano-machines by harnessing thermal fluctuations, and with collaboration with trans-acting proteins, are gaining directed motion, yielding at the same time proteins, as basic bio-molecules. Within the course structural aspects of protein functioning will be presented, together with research pipeline allowing to study protein structure and intermolecular interaction. The auxiliary protein factors for the translational machinery will be considered, including translational GTPases, ribosome-Inactivating-proteins and sensory proteins modulating ribosome activity.
The second part of course is focused on peptides – structures, biosynthesis, physicochemical properties. Antimicrobial peptides - classification, important features, mechanisms of antimicrobial action, role in the host organism. Anticancer peptides. Cell penetrating and mitochondria penetrating peptides. Peptide sequencing. Chemical synthesis of peptides. Architectural synthetic peptides (dendrimers). Peptide databases. Lab module: Different electrophoretic techniques of peptides separation in polyacrylamide gels (denaturing and non-denaturing conditions: 1D SDS/PAGE, 2D IEF-SDS/PAGE, acidic-PAGE, native-PAGE). Detection and comparison of antimicrobial activity of peptides isolated with different methods.
Lab module is focused on methods of purification and activity analysis of protein kinases.
Recommended literature: Articles from the scientific journals recommended by the teacher.

Course name: Molecular Microbiology (USOS Code: B-BMOL.007)
Course coordinator: Dr hab. Iwona Komaniecka, prof. UMCS
Prerequisites: Basic knowledge of general microbiology, genetics and biochemistry.
Course description: During the lecture, the student will learn about molecular basics of microbial life, e.g.: the microbial virulence factors; microbial motility; biofilms; quorum sensing; cyanobacteria and bacterial photosynthesis; symbiosis between bacteria and plants; taxonomy and microorganisms typing – plasmid profiles and methods with PCR technique using; Archaea – the external microorganisms. Laboratories will be concerned on practical aspects of determination of the microbial physiology: iron uptake systems; phage receptors detection; bacterial motility and taxis; biofilms and factors limiting their formation; quorum sensing– detection of autoinductors; bioluminescence effect; bacterium-plant symbiosis (rhizobium – legume plant); microorganisms storage.
Recommended literature: Willey Joanne M., Sherwood Linda M., Woolverton Christopher J. (Eds) Prescott, Harley, and Klein's Microbiology, 7th ed., 2008; David H. David H. Persing, Fred C. Tenover, Randall T. Hayden, Margareta Ieven, Melissa B. Miller, Frederick S. Nolte, Yi-Wei Tang, Alex van Belkum (Eds) – Molecular Microbiology: Diagnostic Principles and Practice, 3rd edition, 2016, ASM Press.

Course name: Advanced biochemistry (USOS Code: B-BMOL.001)
Course coordinator: Dr Marzanna Paździoch-Czochra and Dr hab. Anna Pawlik
Prerequisites: Completed course in biochemistry (basic course).
Course description: Nucleic acids: structure, function, biosynthesis. Protein:, folding, degradation and turnover. Regulation of transcription and translation. Functional roles of protein (hemoglobin, myoglobin, actin, myosin, molecular motors). Pathways of aminoacids biosynthesis and degradation. Overview of nitrogen metabolism. Biosynthesis and degradation of polysachrides. Lipid metabolism: cholesterol and plasma lipoprotein.
Recommended literature: Berg J.M, Tymoczko J.L., Gatto G., Stryer L., Biochemistry, New York: W.H. Freeman and Company, 2015; Voet D., Judith G. Voet, Biochemistry, 4th Edition, 2010; Clark D., Pazdernik N, McGehee M., Molecular Biology. Academic Cell. Elsevier 2019; Cooper G.M, The Cell Molecular Approach, Oxford University Press, 2019.

Course name: Regulation of cellular processes (USOS Code: B-BMOL.002)
Course coordinator: Dr Joanna Strubińska
Prerequisites: Basic knowledge of biochemistry and cell biology.
Course description: The course explores molecular aspects of cell functions such as: regulation of protein folding, transport, activity and degradation; the relation of molecular structure of membranes to differentiation, specialisation and adaptation of cells and their compartments; molecular regulation of cell survival, proliferation, differentiation, adhesion, mobility and death.
Students will conduct experiments connected with molecular reorganization of membranes, regulation of cellular processes like cell division or cell cycle; regulation of plant morphogenesis in vivo and in vitro; photoprotection.
Recommended literature: Molecular biology of the cell. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. New York: Garland Science, fifth or later edition; Current scientific publications.

Course name: Analysis of biomolecules (USOS Code: B-BMOL.003)
Course coordinator: Prof. dr hab. Adam Choma
Prerequisites: Basic knowledge of: 1) chemistry – structure of atoms (fundamental subatomic particles, molecular energy levels); 2) biochemistry – the biomolecule structures (proteins, lipids, polysaccharides, pigments, nucleic acids); 3) analytical chemistry – molar and percentage concentration, molecular weight.
UV-Vis and IR spectroscopy in the analysis of biomolecules: The course provides training in molecular spectroscopy techniques (UV-Vis and IR absorption spectroscopy, fluorescence spectroscopy). Planned experiments: 1) structures of biomolecules and their supramolecular organization (aggregate, dimer, monomer); 2) identification of biomolecules on the basis of UV-Vis and FTIR spectra; 3) calculation of molar concentration and molar absorptivity of biomolecules, 4) proteins UV-Vis absorption and fluorescence, 5) determination of proteins secondary structure on the base of FTIR spectrum.
Mass spectrometry (MS) and Nuclear Magnetic Resonance (NMR) in the analysis of biomolecules: MS – theoretical basis of the method, modular structure and principle of operation of the mass spectrometer, types of ion sources, analysers and detectors, basic ionization techniques, techniques of sample preparation for MS analyses. Analysis and interpretation of mass spectra of selected compounds. Protein identification and sequencing methods using MS and MS/MS techniques. Tissue imaging by mass spectrometry (MS-Imaging).
Nuclear magnetic resonance spectroscopy (NMR) – theoretical basis of proton and carbon one-dimensional spectra (^{1}H and ^{13}C). Application of NMR spectroscopy: identification of simple organic compounds. Two (and more) dimensional homo and heteronuclear spectra . Analysis of simple biopolymers. Principles for determining the spatial structure of proteins. Application of NMR spectroscopy for imaging (MRI).
Selected methods of protein analysis: preparation and characterization of proteins for kinetic analysis; protein separation and purification by liquid chromatography (size exclusion chromatography, ion exchange chromatography, hydrophobic chromatography, affinity chromatography); Protein stability profile - thermal and chemical denaturation; Protein-protein interaction analyses; Bio-layer interferometry (BLI); Microscale thermophoresis (MST)
Recommended literature: Lakowicz J.R. (ed.) Principles of Fluorescence Spectroscopy, Springer, 3rd ed. 2006. Corr. 5th printing 2010; Gryczynski K.Z. Practical Fluorescence Spectroscopy, Taylor & Francis Inc; R.M. Silverstain et al. Spectrometric Identification of Organic Compounds, John Wiley and Sons, 2014; Dass C. Fundamentals of contemporary mass spectrometry John Wiley and Sons, 2007; Manufactures manuals: https://nanotempertech.com/ - Bio-layer interferometry (BLI), https://nanotempertech.com/ - Stability profile - Prometeus, https://www.sartorius.com/ - Microscale thermophoresis (MST).

Course name: Statistical methods in biology (USOS Code: B-BMOL.005)
Course coordinator: Dr hab. Joanna Czarnecka, prof. UMCS
Prerequisites: Basic knowledge of mathematics, ability to use Ms Office.
Course description: Introduction to statistics and the use of Statistica software. Calculation and interpretation of simple descriptive statistics (mean, standard deviation, median, measures of variability, standard error). Preparation and practical usage of histograms. Statistical hypothesis (null and alternative hypothesis) and their verification. The relevance of normal distribution to biological data, checking for normality. The t-test – checking the assumptions: different tests for different data set (repeated measures, independent samples, t-test for one data set). Calculation and interpretation of the t-test results. Analysis of variance (ANOVA), constraints and assumptions, post-hoc testing (repeated measurements and independent samples). Two-way

ANOVA – what to do about results of factorial experiments? Looking at the relationships: correlation and regression (Pearson's correlation and linear regression). What can we do about non normal distribution: non-parametric analysis and tests, selection, execution and interpretation of results. Technique of presentation of scientific data and results of analysis. Introduction to multivariate analysis with MVSP software. Data processing: types of data, import, transformation. Preparing of data matrix. Data classification methods: hierarchical (cluster analysis). Ordination methods: unconstrained (indirect) ordination by example principle components analysis (PCA) and detrended correspondence analysis (DCA). Direct (constrained) ordination techniques by example canonical correspondence analysis (CCA).
Recommended literature: Dytham C. 2011. Choosing and Using Statistics. A Biologist's Guide. Wiley-Blackwell; Kent M. 2012. Vegetation Description and Data Analysis: A Practical Approach. Wiley & Blackwell; Lepš J., Šmilauer P. 2004. Multivariate Analysis of Ecological Data. Course materials. Faculty of Biological Sciences, University of South Bohemia, Českė Budějovice; van Emden H. 2008. Statistics for Terrified Biologists. Blackwell Publishing (literature provided by the teacher).

Course name: Molecular evolution (USOS Code: B-BMOL.004)
Course coordinator: Dr hab. Grzegorz Janusz, prof. UMCS
Prerequisites: Basic knowledge of biochemistry and genetics.
Course description: The aim of this course is to familiarize students with basics of evolution mechanisms, brief history of life, macro- and micro-evolution. During the course, students will gain knowledge of population genetics, DNA and protein evolution, phylogenetics, importance of duplication and molecular tinkering in evolution. Furthermore, prokaryotic and eukaryotic genome evolution will be discussed in details. Finally, evolution of gene expression regulation and experimental evolution will be mentioned.
Recommended literature: Dan Graur "Molecular and Genome Evolution"

Course name: Diploma seminar (I module - Writing and presentation of scientific papers) (USOS Code: B-B.MOL.008a)
Course coordinator: Dr hab. Małgorzata Wójcik, prof. UMCS
Prerequisites: -
Course description: The aim of this course is to familiarize students with types of scientific publications, rules of preparing a diploma thesis as well as preparing and presenting oral and poster presentations. The following issues will be discusses and practised. Types of scientific publications (primary, secondary, tertiary sources), examples. Principles of publication in scientific journals (including formal and legal rules, taking into account intellectual property regulations), analysis of bibliometric parameters of journals, instructions for authors. Structure of scientific papers. Composition, structure and formatting of a diploma thesis, content of particular chapters/sections. Formulating the purpose of the paper, research hypotheses, abstract, summary, conclusions. Literature review (analysis of internet sources and use of various databases including Google Scholar, Scopus, Web of Science, PubMed), principles of literature citation. Manners and principles of presenting results, figures, tables, different types of graphs, proper description and captioning of figures and tables. Principles of a good oral and poster presentation, practical implications, techniques of delivering a public presentation depending on the audience (professionals, non-specialist audiences, different social groups).
Recommended literature: Materials provided by the teacher.

Course name: Training (USOS Code: B-B.171Eng)

Compulsory trainings aimed at students who have started their studies at UMCS for the first time at 1st or 2nd degree studies. The module includes three on-line trainings :

- Work Hygiene and Safety

- Ethics and Disciplinary Liability of Students

- Library Training

Prerequisites: -

Course description: During the **Work Hygiene and Safety** course the student will gain knowledge about selected legal basis related to health and safety of work in universities, elements of ergonomics, physiology and work hygiene, possible risks and their prevention, fire protection rules, and emergency first aid. **Ethics and Disciplinary Liability of Students** course will deal with general issues concerning legal basis of students' disciplinary responsibility, student's ethics, a catalogue of student's rights and duties. During the **Library Training** the student will learn the principles of using the collections and services of the Maria Curie-Skłodowska University Library, gain practical skills in using the Library's offer, will learn how to search for literature useful at any level of study.

Recommended literature: -

2nd semester

Courses	No. of hours	Lecture	Classes	Form of course completion	Credits ECTS	
					O	E
Bioinformatics[3)]	60	-	60 (Lab)	Ex	5	
A) Next-generation sequencing and beyond[3)] or B) Molecular modelling[3)]	30	-	30 (Lab) 30 (Lab)	Ex	-	3
A) Microbial infectivity, drug resistance and diagnostics[2)] or B) Microbial genomics[2)]	30	15 15	15 (Lab) 15 (Lab)	Ex	-	3
Innovations in environmental microbiology and sustainable development	15	15	-	Pg	1	-
Biochemical and molecular ecology	45	15	30 (Lab)	Ex	3	-
Other elective courses (2 to be chosen): 1. Human ecology 2. Animal and plant cell and tissue in vitro cultures 3. Vaccines and plasma-based preparations of therapeutic purpose 4. Host-pathogen interactions	30 30	-	-	Pg	-	3 3
Academic lecture	15	15		Pg	-	1
Foreign language	30		30 (K)	Pg	2	
Research project	100			Pg	7	
Total:	**395**				**18**	**13**
					31	

Forms of classes (L – Lecture, Lab – Laboratory, K – Tutorial, S – Seminar); Ex – exam, Pg – pass with grade; O – obligatory course, E – elective course; 1) 2) 3) elective complementary/extending courses will follow

Course name: Bioinformatics (USOS Code: B-BMOL.012)
Course coordinator: Dr hab. Andrzej Mazur, prof. UMCS
Prerequisites: Basic computer skills, completed courses of genetics, molecular biology or equivalent courses.
Course description: During the course, the student will learn what is the working area of bioinformatics. Issues related to biological primary and secondary databases and their resources, structure and formats of sequence records, searching and retrieving records from databases will be discussed. The basic tool for searching of sequence databases (FASTA, BLAST), pairwise and multiple sequence alignment algorithms and their optimization will be shown. Basics of DNA sequence analysis: searching for motifs, patterns, open reading frames, genes, promoters as well as examples of tools for molecular phylogenetic will be provided. Moreover issues of protein sequence analyses: functional domain searching, examples molecular modeling of proteins and their interactions will be addressed.
Recommended literature: Xiong, J. Essential Bioinformatics. (Cambridge University Press, 2006), Mount, D. W. Bioinformatics: sequence and genome analysis. (Cold Spring Harbor Laboratory Press, 2004), Lesk, A. M. Introduction to bioinformatics. (Oxford University Press, 2014).

Elective complementary/extending courses to Bioinformatics (A or B)

A) Course name: Next-generation sequencing and beyond (USOS Code: B-BMOL.015)
Course coordinator: Dr Piotr Koper
Prerequisites: Basic computer skills; basic knowledge of mathematics and molecular biology.
Course description: The purpose of this course is to get a deeper understanding in Next-Generation Sequencing (NGS) with a special focus on bioinformatics issues. Advantages and disadvantages of current sequencing technologies and their implications on data analysis will be discussed. The participants will be trained on understanding NGS data, finding potential problems/errors therein and perform basic downstream analysis. Basic discussed issues comprise: databases and NGS data formats, quality control and NGS data processing, mapping reads to reference using real sequencing data, processing of mapping results and using them in a specific bioinformatics application.
Recommended literature: Next Generation Sequencing and Data Analysis (Springer International Publishing, 2021), Low, L. & Tammi, M. Bioinformatics: A Practical Handbook of Next Generation Sequencing and Its Applications. (WORLD SCIENTIFIC, 2017), Buffalo, V. Bioinformatics data skills. (O'Reilly, 2015).

B) Course name: Molecular modelling (USOS Code: B-BMOL.016)
Course coordinator: Prof. dr hab. n. farm. Krzysztof Jóźwiak
Prerequisites: Basic knowledge of biochemistry, molecular biology and chemistry.
Course description: The student will have a chance to perceive the fascinating world of biological (macro)molecules and molecular basis of selected biological processes. Aided by specialized molecular modelling software the students will analyse three dimensional structures of selected proteins and how specific structural features of a macromolecule are responsible for its function. Atomic level inspections of drug – protein complexes will provide detailed information on interactions between proteins' active sites and drug molecules indicating molecular mechanisms by which small chemical ligands can manipulate natural functions of target proteins. The course will concentrate on structurally illustrative examples of certain proteolytic enzymes (DD-transpeptidases, angiotensin convertases), receptors (ligand gated ion channels, G-protein coupled receptors etc.) or glucose transporters. At the end, diversified molecular mechanisms

utilized by various naturally occurring toxins targeting proteins at the neuromuscular junction will be presented.
Recommended literature: David Goodsell. The machinery of life, 2010 Edition, https://pdb101.rcsb.org/ PDB educational portal.

Elective complementary/extending courses to Molecular microbiology (A or B)

A) Course name: Microbial infectivity, drug resistance and diagnostics (USOS Code: B-BMOL.013)
Course coordinator: Dr hab. Jolanta Kutkowska, prof. UMCS
Prerequisites: Basic knowledge of microbiology.
Course description: PCR techniques - genetic methods in the diagnosis of bacteria (detection of genes encoding antibiotic resistance and synthesis of toxins as well as virulence factors). Typing strains using the BOX-PCR method. Serological methods in bacterial diagnostics. Techniques for determining antibiotic sensitivity, detection of antibiotic resistance mechanisms by disc and molecular techniques. The importance of MIC in the optimal therapy of infections. Isolation and identification of bacteria from the environment.
Recommended literature: 1) Antibiotic Drug Resistance Editor(s):José-Luis Capelo-Martínez, Gilberto Igrejas ISBN:9781119282549 |DOI:10.1002/9781119282549, John Wiley & Sons, Inc. 2020; 2) Bacterial Pathogens and Their Virulence Factors Douglas I. Johnson ISBN 978-3-319-67651-7 https//doi.org/10.1007/978-3-319-67651-7_1, Springer, Cham 2018; 3) Sherris Medical Microbiology, 7e, editor Kenneth J. Ryan MD, ISBN 978-1-259-85980-9, McGraw Hill 2017. 4) Jawetz, Melnick, & Adelberg's Medical Microbiology, 28e, Editors Stefan Riedel, et al., McGraw Hill; 2019.

B) Course name: Microbial genomics (USOS Code: B-BMOL.014)
Course coordinator: Dr hab. Michał Kalita
Prerequisites: Completed microbiology, genetics or equivalent courses.
Course description: Course description: The theoretical part of the course covers the following topics: Structure and organization of prokaryotic genomes (chromosomes, plasmids). The mobile genetic elements and their role in bacterial genome plasticity and evolution. Microbial mobilome in biotechnology. Mechanisms of HGT - horizontal gene transfer (transformation, conjugation, transduction). Barriers to HGT – CRISPR-Cas and Restriction-Modification (R-M) systems. Introduction to metagenomics and microbiome analysis.
The experimental part covers isolation of plasmids and plasmid profiling, phage typing, genotyping of bacterial strains using PCR based techniques, the routes of gene transfer in practice - conjugation and transduction.
Recommended literature: T.A. Brown - Genomes, 4th Edition.

Course name: Innovations in environmental microbiology and sustainable development (USOS Code: B-BMOL.009)
Course coordinator: Prof. dr Jaco Vangronsveld
Prerequisites: Basic knowledge of microbiology.
Course description: Microorganisms are omnipresent in our environment and have many crucial roles in the functioning of natural and anthropogenic ecosystems. In this course we will start with describing soil, water and air as habitats for microorganisms and also the interactions of microorganisms with other organisms. Microorganisms are involved in many biotechnological processes to protect the environment. Examples will be given of the state-of-the-art and

possibilities of exploiting microorganisms in function of sustainable development. Plant- and microorganism-based technologies to treat polluted soils, waters and air will be described and exemplified in a section on bioremediation. Microbes can also be used to make agriculture more sustainable. They can be adopted as biofertilizers, but also can have a role in plant protection (biopesticides). .
Recommended literature: Some review articles will be made available.

Course name: Biochemical and molecular ecology (USOS Code: B-BMOL.010)
Course coordinator: Dr hab. Grzegorz Janusz, prof. UMCS
Prerequisites: Basic knowledge of biochemistry and genetics.
Course description: The aim of this course is to familiarize students with basics of biochemical interactions between organisms belonging to the same or different species and interactions of organisms with elements of their habitats and environments. Furthermore, during the lectures, students will gain knowledge on molecular populational genetics, molecular phylogenetics, and genomics in relation to traditional ecological questions (e.g., species identification, preservation and assessment of biodiversity, species-biotope relationships, and other questions in behavioral ecology).
Recommended literature: Joanna R. Freeland, Molecular Ecology, 3rd Edition (Willey).

Other elective courses

Course name: Human ecology (USOS Code:B-BMOL.019)
Course coordinator: Dr Magdalena Franczak
Prerequisites: -
Course description: Basics concepts of human ecology. History of the development of human ecology. Human ecology and other sciences. Human as biological and social unit. Biological evolution and human cultural evolution. Forms of human societies. Civilizations. Human population as an element of the ecological system. Biocenotic interactions with other species. Homeostatic mechanisms of the individual and population levels. Environmental factors (abiotic, biotic and social) affecting human development and health. Geographical distribution of human population and the impact of geoclimatic conditions. Genetic, physiological, and social adaptation to the environment and to environmental changes. The development of civilization: demographic and health changes. Effects of population density on health, social organization, and environmental quality. Stress: symptoms and prevention. Ecology of work environment. Ecological aspects of human activity. Ecology and evolution of nutrition.
Recommended literature: Bates D.G., Tucker J. (eds.). 2010. Human ecology: contemporary research and practice. Springer, New York, London; Cameron N., Bogin B. 2012. Human growth and development. Second edition. Academic Press, Elsevier; Frisancho A.R. 1993. Human adaptation and accommodation. The University of Michigan Press, Ann Arbor.

Course name: Vaccines and plasma-based preparations of therapeutic purpose (USOS Code: B-BMOL.018)
Course coordinator: Dr Magdalena Mizerska-Kowalska
Prerequisites: General knowledge of virology and human immunology.
Course description: Vaccines - the history and definition, the schemes of development and clinical trials, the components of vaccines and their roles, the currently available types of vaccines, the new types of vaccines, the characteristic of chosen vaccines. Plasma-based preparations - the

history and definition, the production of human immune globulin, albumin, and coagulation factor concentrates (methods, steps and restrictions/regulations), the therapeutic purposes.
Recommended literature: Vaccinology: An Essential Guide, Materials, i.e. review papers provided by the teacher.

Course name: **Animal and plant cell and tissue *in vitro* cultures (USOS Code: B-BMOL.020)**
Course coordinators: Dr Mateusz Pięt, Dr Kinga Lewtak
Prerequisites: Cellular biology.
Course description: Plant part: Methods of in vitro plant propagation by induced organogenesis and somatic embryogenesis. Hormonal control of plant cell growth and development. The use of plant tissue cultures in biotechnology (somatic hybridization, haploid plant production, obtaining biologically active plant secondary metabolites). Plant stem cells. The phenomenon of somaclonal variation in the plant cloning process. Animal part: In vitro cultures as a model in the study of normal and cancer cell biology. Methods and techniques of in vitro cells and tissues culture - basics of adherent and non-adherent cultures. Methods used in the study of cancer biology at the cellular level (assessment of cell viability, proliferation, migration) and molecular level (assessment of the level, concentration, activity of proteins and gene expression). Techniques and methods for forming and maintaining 3D cultures.
Recommended literature: Imani J, Kumar A, Neumann K. 2009. Plant Cell and Tissue Culture - A Tool in Biotechnology. Basics and Application (1st ed.). Springer, Berlin, Heidelberg. Chandra S, Lata H, Varma A. 2013. Biotechnology for Medicinal Plants. Micropropagation and Improvement (1st ed.). Springer, Berlin, Heidelberg (Chapters 6, 8, 9). Vunjak-Novakovic G, Freshney IR. 2006. Culture of Cells for Tissue Engineering (1st ed.). John Wiley & Sons: Chapter 1 – Basic Principles of Cell Culture (Freshney IR, p. 3-22). Wilson K, Walker J. 2010. Principles and Techniques of Biochemistry and Molecular Biology (7th ed.). Cambridge University Press.

Course name: **Host-pathogen interactions (USOS Code: B-BMOL.017)**
Course coordinator: Dr hab. Aneta Ptaszyńska, prof. UMCS
Prerequisites: Basic knowledge of microbiology.
Course description: The aim of this course is to familiarize students with host-pathogen interactions and the latest techniques on their studies. Students will know the types of pathogens and their strategies for interaction with the host, molecular mechanisms of virulence, characteristics of the host-pathogen interaction, adaptive properties of pathogens, effect of anthropopressure on host-pathogen interactions, the Red Queen theory, threats and hopes related to "gain-of-function" research and GMO research, and future directions in studying host-pathogen interactions. Additionally, students will have practical training on the detection and analysing of host-pathogen interaction using *Galeria mellonella* model and selected bacteria and fungi.
Recommended literature: PDF materials prepared for the course by the teacher; Black Jacquelyn G. - Microbiology. Principles and Explorations, 8 th ed., 2012; Madigan Michael T., Martinko John M., Bender Kelly S., Buckley Daniel H., Stahl. David A. (Eds) - Brock Biology of Microorganisms, 14th ed., 2015; John Wiley & Sons, New York; Deacon J. 2006. Fungal biology. 4th edition, Blackwell Publishing; Ingold C.T. 1961. The Biology of Fungi, Hutchinson Educational; Male D., Brostoff J., Roth D., Roitt I. (eds) Immunology 8th edition, Imprint: Saunders, Published Date: 17th September 2012.

Course name: Academic lecture
Course coordinator:

Prerequisites: -
Course description: Every semester a new offer of academic lectures is prepared. Students may register to a selected lecture according to his/her interest providing the fact that the lecture is not assigned to the discipline of study (biology). The lectures are open for the whole academic society and are conducted by the best lecturers from all faculties of the University.

Course name: Research project (USOS Code: B-BMOL.021a)
Course coordinator: A project supervisor
Prerequisites: -
Course description: The Master's degree programme culminates in a Master's thesis, prepared on the basis of the student's individual research project. The research project is realised for three semesters under supervision of an experienced research supervisor. The topic of the research project, methodology and the individual research plan are agreed with the supervisor. Students are expected to perform original research, using modern and adequate experimental methods to solve a given task, collect data and analyse them applying appropriate statistical treatment. Upon completion of the practical work, the students will write a diploma thesis, presenting their results in the form of scientific dissertation. The dissertation includes state-of-the-art, description of the methods and the results, followed by the discussion and interpretation of the obtained results in view of relevant scientific literature.

2nd year

3rd semester

Courses	No. of hours	Lecture	Classes	Form of course completion	Credits ECTS	
					O	E
Molecular biology in entrepreneurship	15	-	15 (K)	Pg	1	-
A) Protein bioengineering[1)] or B) Current topics in cell signaling[1)]	30	10 -	20 (Lab) 30 (K)	Ex	-	3
Elective courses in Humanities (two courses to be chosen from the given list)	60	60	-	Pg	-	4
Diploma seminar (II module)	30		30 (S)	Pg	3	-
Research project	120		120 (Lab)	Pg	8	-
Foreign language	30		30 (K)	Ex	2	-
Theme Module I or Module II **Module I** (*Molecular biology for environment and industry*) 1. Molecular mechanisms of adaptation 2. Biocatalysis and biotransformation **Module II** (*Molecular biology for medicine*) 1. Medical genetics and molecular diagnostics 2. Development of biomolecules with desired characteristics	 45 45	 15 15	 30 (Lab) 30 (Lab)	Pg		 4 4
Total:	**375**				**14**	**15**
					29	

Forms of classes (L – Lecture, Lab – Laboratory, K – Tutorial, S – Seminar); Ex – exam, Pg – pass with grade; O – obligatory course, E – elective course; 1) 2) 3) elective complementary/extending courses will follow

Course name: Molecular biology in entrepreneurship (USOS Code: B-BMOL.022)
Course coordinator: Prof. dr hab. Anna Jarosz-Wilkołazka
Prerequisites: Advanced biochemistry, Regulation of cellular processes, Molecular microbiology
Course description: the presentation of the basic principles of biochemical reaction engineering and molecular biology processes for the analysis and design of metabolic pathways to achieve specific goals e.g. increase the productivity of living organisms to obtain natural metabolites; analysis at the molecular, microscopic and macroscopic level; examples of metabolites obtained from processes optimised by metabolic engineering techniques (heterologous proteins, biopolymers, synthesis of chiral compounds, selected secondary metabolites of plants and microorganisms). In biotech and pharmaceutical sector necessary are knowledge and practical skills in biosciences but also a strong understanding of entrepreneurship and decision-making given the opportunities available.
Recommended literature: PDF materials prepared for the course by the teacher.

Course name: Protein bioengineering (USOS Code: B-BMOL.023)
Course coordinator: Dr Przemysław Grela
Prerequisites: basic knowledge of genetics and biochemistry
Course description: The aim of the lectures to acknowledge the students with the theoretical and practical basics of protein structure, function, and regulation of biological process dependent on proteins functioning, especially focusing on recombinant protein expression with the aim of developing innovative biomaterials for biotechnological applications.
The laboratory course includes: homologous and heterologous protein expression techniques and purification process using liquid chromatography (size exclusion chromatography, ion exchange chromatography, hydrophobic chromatography, affinity chromatography); protein bio-physical analysis - circular dichroism, nano-differential-scanning-fluorimetry, protein mass spectrometry; SDS/PAGE, western blotting.
Recommended literature: Articles from the scientific journals recommended by the teacher

Course name: Current topics in cell signalling (USOS Code: B-BMOL.024)
Course coordinator: Dr Dawid Krokowski
Prerequisites: basic knowledge of genetics and biochemistry
Course description: The following topics will be discussed during the classes: 1) **Sensing hunger on cellular level –** Methods to assess activation of signalling pathways; Steady state levels of metabolites. 2) **Starving cancer to death. Targeting metabolism as a concept of cancer treatment –** Measurement of metabolic fluxes using stable isotope labelled Glucose. 3) **Stress-dependent alternation of metabolism. Why all cellular stressors change amino acid homeostasis? –** Measurement of metabolic fluxes using stable isotope labelled Glutamine. 4) **When abundance harms your health. Alternation in metabolism and disease development –** Methods for lipids quantification and Lipidomics; Metabolomics methods. 5) **Amino acids and related metabolites. From allosteric modulators to neurotransmitters –** New concepts of ammonia disposal in mammals; Metabolites in gut-brain signalling.
Recommended literature: Ye et al. (2010) The GCN2-ATF4 pathway is critical for tumor cell survival and proliferation in response to nutrient deprivation The EMBO Journal; van Leeuwen et al. Amino Acid Depletion Therapies: Starving Cancer Cells to Death (2021) Trends Endocrinol. Metab.; Yoo et al. Glutamine reliance in cell metabolism (2020) Exp. Mol Med.; Gil et al. Are we close to defining a metabolomic signature of human obesity? A systematic review of metabolomics studies (2019) Metabolomics; Benjamin et al. Fasting induces a highly resilient deep quiescent state in muscle stem cells via ketone body signaling. Cell Metab.; Mayneris-Perxachs et al. Microbiota alterations in proline metabolism impact depression (2022) Cell Metab. (2022).

Theme Module I (Molecular biology for environment and industry)

Course name: Molecular mechanisms of adaptation (USOS Code: B-BMOL.025)
Course coordinator: D r hab. Agnieszka Zdybicka-Barabas
Prerequisites: Basic knowledge of biochemistry, molecular biology and genetics
Course description: During the lecture, the student will learn about the following topics: Adaptation – concept, types. Gene expression regulated by changes in the external environment. Adaptive genes and their products. The role of the proteome in adaptation.
The student will perform experiments and observations according to the instructions presented in the scripts and under the guidance of the teacher. The laboratory covers the following topics: Proteome analysis of tissues isolated from *Galleria mellonella* larvae, and identification of selected proteins. Detection and analysis of proteolytic and antimicrobial activity in prepared biological materials.
Recommended literature: Selected articles from the current scientific literature available in electronic version recommended by the teacher.

Course name: Biocatalysis and biotransformation (USOS Code: B-BMOL.026)
Course coordinator: Prof. dr hab. Anna Jarosz-Wilkołazka
Prerequisites: Completed courses of Advanced biochemistry and Regulation of cellular processes
Course description: The presentation of enzymes and biocatalysis with their applications in various industrial processes including environmental processes. The basic issue are: introduction to enzymes and enzyme catalysed reactions; classification and mechanism of reaction; purification and characterization of enzymes; example of industrial enzymes; applications of enzymes in diagnostics, analysis, biosensors, biocells and other industrial processes and biotransformations; enzyme structure determination, stability and stabilisation; enzyme immobilization and concept of enzyme engineering; nanobiocatalysis.
Recommended literature: Buchholz K., Kasche V., Bornscheuer U. Biocatalysts and Enzyme Technology. Wiley-Blackwell, 2012; Minteer S. D. (ed) Enzyme stabilization and Immobilization. Methods and Protocols. Humana Press, 2011.

Theme Module II (Molecular biology for medicine)

Course name: Medical genetics and molecular diagnostics (USOS Code: B-BMOL.027)
Course coordinator: Dr hab. Malgorzata Marczak
Prerequisites: Basic knowledge of genetics and genetic engineering
Course description: Types of inheritance of genetic diseases and basics of calculating the disease risk. Molecular basis of monogenic and mitochondrial diseases. Molecular pathology in recessive and dominant inheritance. Genomic imprinting. Epigenetic diseases. Basic tools used in human genetics. Genetic diagnostics, indications for performing a genetic test, genetic test variants, algorithm in diagnostics: from phenotype to identification of the molecular basis of the disease. Complex diseases with a defined genetic and environmental component, twin studies, heritability. Human karyotype. Classical and molecular cytogenetic techniques in the diagnosis of chromosome syndromes. Perspectives of personalized medical genetics.
Recommended literature: Materials prepared for the course by the teacher. Thompson & Thompson “Genetics in Medicine”, 8th Edition, Robert Nussbaum & Roderick R. McInnes & Huntington F. Willard.

Course name: Development of biomolecules with desired characteristics (USOS Code: B-BMOL.028)
Course coordinator: Prof. dr hab. Małgorzata Cytryńska
Prerequisites: Basic knowledge of biochemistry, microbiology, and genetics
Course description: Strategies for the development of new, biologically active peptides. Natural antimicrobial peptides (AMPs) as patterns for the development of highly active antimicrobial and antitumor molecules. Combinatorial libraries. Peptidomimetics. Directed evolution of peptides and proteins – technologies: phage display, ribosome display, mRNA display, SNAP-tag display. Aptamers – selection (SELEX techniques) and application. Lab module: Testing and comparison of antimicrobial action of selected native and synthetic peptides (cell membrane permeabilizing activity, Live/Dead fluorescent staining of bacteria and fungi – imaging by Laser Scanning Confocal Microscopy, analysis of cell surface topography and nanomechanical properties by Atomic Force Microscopy).
Recommended literature: Articles from the scientific journals recommended by the teacher.

4th semester

Courses	No. of hours	Lecture	Classes	Form of course completion	Credits ECTS	
					O	E
Synthetic biology	30	-	30 (K)	Ex	2	
Theme Module I or Module II **Module I** (*Molecular biology for environment and industry*) 1. Industrial microbiology 2. Biological control of plants **Module II** (*Molecular biology for medicine*) 1. Cellular and molecular immunobiology 2. Tumor biology	 45 45	 15 15	 30 (Lab) 30 (Lab)	Pg	-	 4 4
Diploma seminar (III module)	30	-	30 (S)	Pg	3	-
Research project	160	-	160 (Lab)	Pg	10	-
Diploma thesis and final exam					8	
Total:	**310**				**23**	**8**
					31	

Forms of classes (L – Lecture, Lab – Laboratory, K – Tutorial, S – Seminar); Ex – exam, Pg – pass with grade; O – obligatory course, E – elective course

Course name: Synthetic biology (USOS Code: B-BMOL.029)
Course coordinator: Dr Adolfo Rivero-Muller
Prerequisites: Basic knowledge of genetics and biochemistry
Course description: Synthetic Biology (SynBio) is a relatively new field where we redesign biology to regulate or obtain new functions or abilities. The goals of SynBio are to understand biology by re-/de-construction and to create new biological processes with new functions. To achieve this, we adapt natural and/or synthetic systems that can be incorporated into circuits or cellular networks. The goal of this course is to set the basis on how to bioengineer circuits that can regulate and respond to inputs/outputs in a logical and predictable way. In addition, we will discuss the concepts of reconstructing biological systems as single cells as well as in consortia. The course covers many aspects of molecular and cell biology of prokaryotes and eukaryotes. Lectures: Introduction to SynBio; How organisms work; The molecular biology Dogma MODULES (DNA, RNA, proteins); DNA parts – cloning; Gene regulation (promoter, enhancer, inhibitor,

terminator); Transcriptional regulators (factors and inhibitors); Basic Logic Gates (AND, OR, NOR, etc); Multi-logic gates (Multiple logic output); Genome engineering; Signalling networks (ligands/hormones, receptors, cell-cell interactions, etc). Seminars: Gene regulation; Positive/Negative feedback loops; Oscillators and toggle switches; Posttranscriptional modulation; Posttranslational modulation; Input types; Synthetic cell communication.
Recommended literature: Articles from the scientific journals recommended by the teacher

Theme Module I (Molecular biology for environment and industry)

Course name: Industrial microbiology (USOS Code: B-BMOL.030)
Course coordinator: Dr hab. Mariusz Trytek, prof. UMCS
Prerequisites: General knowledge in microbiology, chemistry and biotechnology at high school level
Course description: The aim of this course is to familiarize students with molecular characterization of genomes and proteomes of bacteria and fungi, including model microorganisms used in chemical, pharmaceutical and food industry. The course will deal with overview of microbial cell factories and molecular techniques for detection and selection of highly effective strains in industrial processes. The basic issues are:
1) Bacteria as industrial producers of recombinant proteins and natural products: gene expression and secretion of heterologous proteins; biosynthesis of amino acids, induction and selection of auxotrophic mutants; production of biopharmaceuticals, enzymes, biopolymers, organic acids and other valuable chemicals; 2) Filamentous fungi and yeasts as an industrial workhorse: antibiotic biosynthesis by natural and GMO strains; recombinant vaccine and therapeutic protein manufacture in yeast cells; industrial food and feed enzymes and proteins; flavour and fragrance compounds, organic acids and vitamins; 3) Strain improvement for fermentation and biocatalysis processes; acetone-butanol-ethanol (ABE) fermentation, biotransformations of organic compounds.
In the course of laboratory exercises, the student will perform experiments and observations on his own under the guidance of the teacher to illustrate the applications of genetically modified microorganisms in industrial biotechnology.
Recommended literature: Industrial Microbiology. David B. Wilson Hermann, Sahm K. Peter Stahmann, 2020; Basic biotechnology. Ratledge, C., Kristiansen, B (eds.), Cambridge University Press, 2006; Upstream Industrial Biotechnology Vol. 1: Expression Systems and Process Development. Michael C. Flickinger (ed.), John Wiley & Sons Inc. 2013; 21st Century Guidebook to Fungi David Moore Geoffrey D. (2020) (ISBN 9781108745680), Bacterial Genetics and Genomics, Lori Snyder (2020) (ISBN 9780367263768); Genomy TA Brown PWN 2019.

Course name: **Biological control of plants (USOS Code: B-BMOL.032)**
Course coordinator: Dr hab. Jolanta Jaroszuk-Ściseł, prof. UMCS
Prerequisites: Basic knowledge of general microbiology
Course description: The course aims to indicate the need for agricultural use of methods for reduction of plant diseases and pest control that ensure environmental balance and protect human health through limitation of the use of chemical pesticides in accordance with the idea of Integrated Pest Management (IPM). It will provide knowledge of the molecular basis of different direct and indirect mechanisms of plant-pathogen control, types of plant pathogens, their mechanisms of action, and various biocontrol approaches employing a range of microorganisms and their byproducts and the formation of Biological Control Factors (BCA), which should have the characteristics of microbial biofertilizers: bacteria, unicellular and filamentous fungi (e.g.

mycorrhizal fungi), bacteriophages, and mycoviruses. It will elucidate the role of optimized microbiomes, genetically modified biocontrol techniques, and microbiome engineering. It will indicate the importance of obtaining improved disease-resistant plant varieties and inducing plant resistance through biopreparations composed of elicitors of microbial and plant origin. The course will present the legal principles of marketing biocontrol preparations in various types of agriculture.
Lab classes will offer a possibility of practical testing methods for isolation of rhizosphere and endophytic microorganisms described the scripts, screening biocontrol and biostimulation features, and using techniques of obtaining microbial consortia and plant resistance elicitors of various origins and their application in plants.
Recommended literature: PDF materials prepared for the course by the teacher and the latest original and review scientific papers published in renowned journals and available on-line.

Theme Module II (Molecular biology for medicine)

Course name: Cellular and molecular immunobiology (USOS Code: B-BMOL.031)
Course coordinator: Dr hab. Roman Paduch, prof. UMCS; Dr hab. Iwona Wojda, prof. UMCS
Prerequisites: -
Course description: Molecular aspects of immunity - innate and acquired. Different strategies for 'remembering' infections: CRISP/Cas system in bacteria and its use in biotechnology, Dscam receptors in insects, VLR receptors in jawless. Molecular aspects of somatic gene rearrangement in vertebrates as a result of transposone incorporation. Insects as objects for studying the mechanisms of innate immunity and as a source of bioactive compounds. In vivo RNA interference technique for screening if immune-regulated genes. Molecular basis of the basic components of the immune system synthesis and molecular basis of the interaction of immunologically competent cells in response to antigens. Genetic and molecular aspects of the synthesis of basic receptors and cytokines involved in the recognition of antigens. Intercellular interactions and paracrine interactions in immune reactions in the presence of different groups of antigens. Immunology of selected diseases.
Recommended literature: Abbas A.K, Lichtman A.H, Pillai S. Cellular and Molecular Immunology, 10th Ed. 2021, Elsevier LTD, Oxford. Delves P.J, Martin S.J, Burton D.R, Roitt I.M. Roitt's Essential Immunology, 2017, Wiley-Blackwell.

Course name: **Tumor biology (USOS Code: B-BMOL.033)**
Course coordinator: Dr hab. Roman Paduch, prof. UMCS
Prerequisites: -
Course description: Genetic and molecular aspects related to neoplastic transformation. Cell changes ascribed to particular stages of the carcinogenesis. Cells of the immune system and soluble mediators associated with neoplastic growth. Tumor differentiation based on cell morphology as well as variability of TSA and TAA markers. Molecular properties related to the malignancy of tumors in selected examples. Cell pathways related to the growth, survival and mobility of transformed cells. Molecular and cellular basis of EMT and MET processes. Cellular and receptor changes related to neoplastic metastasis. The mechanism of the spread of neoplastic cells depending on the migration route. Cellular and molecular aspects of targeted migration of neoplastic cells to specific organs. Targeted, molecular and genetic methods of diagnosis and treatment of cancer patients.
Recommended literature: Molls M., Vaupel P., Nieder C., Anscher M.S. eds The impact of tumor biology on cancer treatment and multidisciplinary strategies. 2009, Springer - Verlag Heidelberg.